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ORIGINAL ARTICLE

Potential Distribution Modeling and Morphology of *Pelias barani* (Böhme and Joger, 1983) in Turkey

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Abstract The climatic preferences of *Pelias barani*, a rare Pontic endemic viper, are analysed and a new locality record is reported. According to species distribution modeling, with the average test AUC was was 0.904 ± 0.068, bioclimatic variables such as Precipitation of driest month (45.5%), Temperature seasonality (18.9%), Precipitation seasonality (17.9%) and Maximum temperature of warmest period (14.7%) appear to have the most useful information on geographic distribution of *Pelias barani*. Distribution models of *Pelias barani* under current climatic conditions showed better adaptation to the northwest and northeast part of Turkey.

Keywords Climate, Maxent, New locality, *Pelias barani*, Rize, Turkey, Vipera

1. Introduction

The family Viperidae includes three subfamilies, thirty-eight genera (Pyron *et al.*, 2013) and 328 species (from The Reptile Database 2014). The genus *Vipera* (Laurenti, 1768) includes 32 species inhabiting Asia Minor, Eurasia, Northern Africa and the Middle East (Ananjeva *et al.*, 2006; from The Reptile Database 2014). Currently, 14-15 species belonging to the family Viperidae have been recognized in Turkey (Tuniyev *et al*, 2012, Göçmen *et al.*, 2014). Taxonomically, the genus *Pelias* was recognized first as a subgenus of genus *Vipera* (Venchi and Sindaco, 2006), and many authors used "*Pelias*" as subgenus (Ananjeva *et al.*, 2006; Venchi and Sindaco, 2006; Afsar and Afsar, 2009; Avcı *et al.*, 2010), but later according to a catalogue of living and extinct species in recent years (Wallach *et al.*, 2014), *Pelias* was recognized as a genus in the family Viperidae that includes *P. altaica*, *P. anatolica*, *P. barani*, *P. berus*, *P. darevskii*, *P. dinniki*, *P. ebneri*, *P. eriwanensis*, *P. kaznakovi*, *P. lotievi*, *P. magnifica*, *P. nikolskii*, *P. olguni*, *P. orlovi*, *P. pontica*, *P. renardi*, *P. sachalinensis*, *P. seoanei*, *and P. ursinii* species (Wallach *et al.*, 2014). Accordingly, I use *Pelias* as genus in this study. *Pelias barani* (Baran's Adder) is one of the Anatolian vipers with little information available about its biology (Kumlutaş *et al.*, 2012). *P. barani* was first described from its type locality in 60 km N of Adapazarı at 400 m a.s.l. (40°50' N, 30°25' E) in the northwestern Anatolia with a female specimen (Böhme and Joger, 1983). Later, new locality records were reported from the northwestern and the northeastern Anatolia (Baran *et al.*, 1997; Franzen and Heckes, 2000; Baran *et al.*, 2001; Avcı *et al.*, 2004; Baran *et al.*, 2005; Kumlutaş *et al.*, 2012) (Table 1). The taxonomic status of *P. barani* was evaluated with several studies in respect to phylogenetic data. Firstly, Joger *et al.* (1997) studied the phylogenetic position of *P. barani* and *P. nikolskii* within the *P. berus* complex using morphological and hemipenial comparisons, and a partial sequence of the mitochondrial cyt *b* gene. According to mitochondrial DNA information, they found that *P. barani* might be a subspecies of *P. berus*, but they showed that it was a different species using both morphological and hemipenial data. Later, Joger *et al.* (2003) identified five groups including *P. barani*, and genus *Pelias* that is consisted basically of two lineages covering *P. berus* and *P. ursinii-kaznakowi* complex. Secondly, Kalyabina-Hauf *et al.* (2004) studied systematic phylogeny of *P. berus* complex, and they found that *P. bosniensis* and *P. barani* were morphologically different from *P. bersus* and are suspected to be a

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Table 1 Morphometric measurements and counts of known specimens based on literature information together with new locality. SSO: Scales between supraoculars, EUL: Scale rows between eyes and upper labials, DS: longitudinal rows of dorsal scales. References: 1) Böhme and Joger (1983), 2) Baran *et al.* (1997), 3) Franzen and Heckes (2000), 4) Baran *et al.* (2001), 5) Avci *et al.* (2004), 6) Baran *et al.* (2005), 7) Kumlutaş *et al.* (2012), 8) This study

References	1	2		3			4		5	6	7	8
Localities	60 km N of Adapazarı	Camlıhemşin Ardeşen	Dereli Giresun	Dereli Giresun	Fırtına Valley, Ardeşen	Arpagözü Çaykara Trabzon	Arpagözü Çaykara Trabzon	The northwest of Artvin	İkizce Ordu	Geyve Adapazarı	Kozlu Zonguldak	Büyükköy Çayeli Rize
Sex	Female	Female	Female	Male	Female	Female	Female	Male	Male	Female	Male	Femlae
SVL	472 mm	426 mm	605 mm	545 mm	595 mm	514 mm	395 mm	no	415 mm	503 mm	460 mm	600 mm
Tail length	68 mm	50 mm	68 mm	73 mm	65 mm	69 mm	51 mm	no	57 mm	62 mm	60 mm	70 mm
Ventrals	145	145	146	142	145	142	142	145	147	145	145	142
Subcaudals	37/37	31/31	31/30	36/36	31/30	28/29	25/28	35/36	34/35	33/33	33/34	29/30
Loreal scales	5/5	5/5	4/4	5/4	11/9	5/5	4/5	4/5	4/5	5/5	4/4	5/5
Circumoculars	11/12	12/12	9/9	11/10	11/10	9/8	9/9	11/12	12/13	11/13	11/13	11/12
Apicals	2	no	no	no	no	1 (2)	2	2	2	2	2	2
Upper labials	10/10	9/9	9/10	9/8	9/9	9/7	9/8	8/9	9/9	9/9	9/9	9/9
Lower labials	12/12	11/11	11/11	12/12	12/13	9/9	10/11	10/10	12/12	11/11	12/12	11/12
Gulars	no	4/4	4/4	4/4	4/4	5/4	5/6	no	4/4	no	4/4	4/4
Canthals	3/3	2/2	2/2	2/2	2/2	2/2	2/2	no	no	2/2	2/2	2/2
SSO	5	no	no	no	no	4	5	no	4	no	5	5
EUL	1/1	no	no	no	no	1/1	1/1	no	1/1	no	1/1	1/1
DS	21	21	21	21	23	21	21	23	22	no	23	21

different species of them. In addition, they reported that if *P. barani* would be recognized a separate species, *P. barani* was supported as paraphyletic, with *P. berus*. Finally, Garrigues *et al.* (2005) indicated that molecular phylogeny of genus *Vipera*, which has three main branches of the European clade, were distinguished the *Pelias* group including *P. barani*, *Vipera ammodytes*, and *Vipera aspis*.

Species distribution modeling creates an expected distribution map of a species based on climatic and others environmental conditions known presence localities (Kozak *et al.*, 2008). It is also useful for conservation strategies and selection of protected areas (Gül, 2013) as well as the relationship between divergence and speciation mechanisms, potential geographic distributions of species on speciation (Graham *et al.*, 2004).

In the text the main goal is to define the climatic patterns and factors affecting species distribution. Therefore, I ran species distribution modeling by Maxent (Philips *et al.*, 2006) because knowledge about the geographical distribution of *P. barani* is crucial for conservation and spatial planning.

2. Materials and Methods

2.1 Studied Species A female *Pelias barani* specimen was found in village Büyükköy of Çayeli, Rize, at 529 m above sea level, on October 18, 2014 by Rahime USTABAŞ from Twelfth Region Headship in Rize under Ministry of Forest and Water Affairs (Figure 1). After analysis of morphological features of the specimen (Table 1) at the Zoology Research Laboratory, Recep Tayyip Erdoğan University, it was safely released back into its natural habitat.

2.2 Environmental Variables 19 bioclimatic variables were downloaded from global climate layers (available at www.worldclim.org) in the highest resolution at 30 arc-seconds (~1 km) under current conditions (~1950–2000) (Hijmans *et al.*, 2005). The global climate layers were clipped to the borders of Turkey using Extract by Mask in ArcGis v. 10.1. Many of the bioclimatic variables are very similar to each other. Therefore, all bioclimatic variables were examined for Pearson correlation coefficient ($0.75 < r < -0.75$) using ENMTools 1.3 (Warren *et al.*, 2010) and redundant variables were excluded. Six bioclimatic variables were eventually selected for the model (Table 2).

Species distribution modeling was performed using Maxent software v. 3.3.3e (Philips *et al.*, 2006). In order to develop species distribution modeling, 10 presence localities were used based on the new locality record

Table 2 Pearson correlation coefficients among bioclimatic variables in Turkey. The pairs of variables with high correlation i.e. 0.75 < r < -0.75 are highlighted and * indicates variables used for model.

Variables	Bio1	Bio2*	Bio3	Bio4*	Bio5*	Bio6	Bio7	Bio8*	Bio9	Bio10	Bio11	Bio12	Bio13	Bio14*	Bio15*	Bio16	Bio17	Bio18
Bio19	0.592902	–0.27924	0.142076	–0.24582	0.401834	0.628766	–0.35574	–0.22007	0.460819	0.530485	0.62239	0.793978	0.936443	–0.14219	0.687766	0.945391	–0.1358	–0.24115
Bio19		–0.06126	0.303975	–0.21101	0.83651	0.932513	–0.28972	0.18495	0.785505	0.943023	0.951781	0.226211	0.405012	–0.31183	0.569387	0.422907	–0.29208	–0.37188
Bio2			0.378344	0.388618	0.329121	–0.28209	0.663325	0.036995	0.013735	0.06216	–0.19129	–0.54857	–0.32332	–0.51099	0.239254	–0.33021	–0.52354	–0.41781
Bio3				–0.68198	0.076629	0.42612	–0.4346	0.181795	0.093947	0.074108	0.468971	–0.1466	0.048688	–0.04659	0.057409	0.006797	–0.00806	0.037818
Bio4					0.31286	–0.52431	0.937364	–0.16921	0.038069	0.123262	–0.49657	–0.23022	–0.21582	–0.4245	0.24437	–0.1781	–0.4728	–0.44755
Bio5						0.59626	0.274694	0.091644	0.776145	0.954578	0.643288	–0.00073	0.222915	–0.5978	0.701526	0.255232	–0.60258	–0.64961
Bio6							–0.60812	0.171466	0.681413	0.772051	0.993062	0.326318	0.452672	–0.09945	0.403664	0.457982	–0.06773	–0.15759
Bio7								–0.11475	–0.04866	0.019226	–0.55331	–0.39157	–0.32175	–0.47202	0.210225	–0.29615	–0.51473	–0.45362
Bio8									–0.00529	0.112856	0.198243	–0.18661	–0.14075	0.111935	–0.17381	–0.15283	0.143028	0.179306
Bio9										0.81503	0.688374	0.076838	0.243253	–0.52227	0.569111	0.267666	–0.50923	–0.6261
Bio10											0.799825	0.162734	0.349802	–0.46114	0.669578	0.380806	–0.45807	–0.5361
Bio11												0.296145	0.449655	–0.1417	0.442061	0.45422	–0.10967	–0.19598
Bio12													0.866645	0.358289	0.246037	0.884633	0.363421	0.23668
Bio13														0.006454	0.607465	0.992375	0.012986	–0.09781
Bio14															–0.71967	–0.0021	0.990916	0.938923
Bio15																0.618829	–0.73199	–0.76438
Bio16																	0.001713	–0.11083
Bio17																		0.944112

Figure 1 Overview of female *Pelias barani* from Büyükköy, Çayeli.

and literature data (Figure 2, Table 3). Seven test points similar to presence localities were created by using Geospatial Modeling Environment version 0.7.2.0 (Beyer, 2012). The final model was composed of the average the AUC of ten replicates.

3. Results

3.1 Morphology of the new specimen of *Pelias barani* The number of ventral scales of the specimen caught from Çayeli is 142 and the number of subcaudal scales is 29–30. The scales on longitudinal rows of dorsal at mid-body were 21. The specimen had two apicals in contact with rostral and also had two canthals on each side of the head. Loreal scales between the preocular and the postnasal were 5–5. Circumocular scales around the eye were 11–12 in the specimen. Upper and lower labials of the specimen were 9–9 and 11–12, respectively. Gular scales that are in contact with the first ventral scales were 4–4. The specimen had a total length of 670 mm (head and body length 600 mm; tail length 70 mm) (Table 1).

3.2 Color patterns of *Pelias barani* The head of the female specimen captured in Çayeli is large (Figure

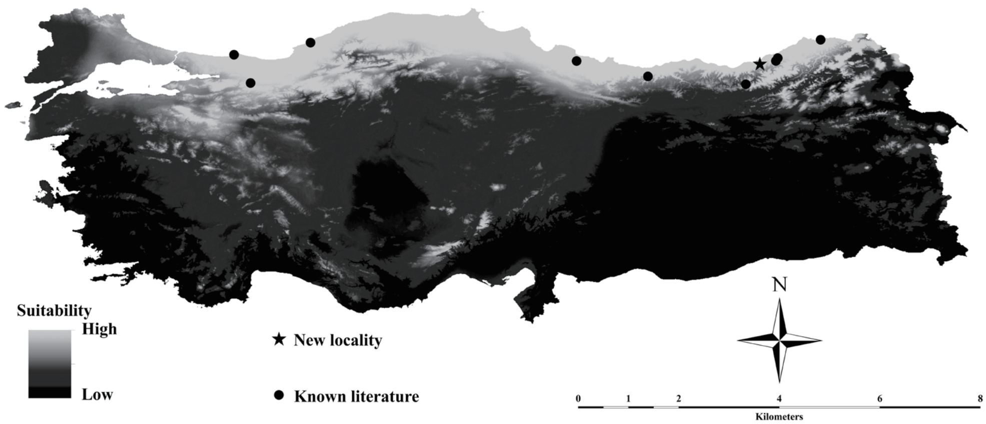

Figure 2 This picture is a representation of the model for *Pelias barani* based on both literature data and new locality record. Warmer colors show areas with better predicted conditions.

Table 3 Localities information of *Pelias barani* based on literatures data.

Species	Latitude	Longitude	Localities	References
P. barani	41.172167	30.227777	60 km N of Adapazarı	Bohme and Joger, 1983
P. barani	41.0462273	37.0433088	İkizce, Ordu	Avcı *et al.*, 2004
P. barani	40.584711	40.410233	Arpagözü Yaylasi, Çaykara, Trabzon	Baran *et al.*, 2001
P. barani	40.6090956	30.5564713	Göktepe, Geyve, Adapazarı	Baran *et al.*, 2005
P. barani	41.4129954	31.7502575	Kozlu, Zonguldak	Kumlutaş *et al.*, 2013
P. barani	40.7397124	38.4615057	Dereli, Giresun	Franzen and Heckes, 2000
P. barani	41.105277	41.044452	Duygulu köyü, Çamlıhemşin, Ardeşen	Baran *et al.*, 1997
P. barani	41.0487107	41.007611	Fırtına valley, Ardeşen, Rize	Franzen and Heckes, 2000
P. barani	41.4699826	41.8979419	The northwest of Artvin	Baran *et al.*, 2001
P. barani	40.994275	40.691457	Büyükköy, Çayeli, Rize	This study

3A). The dorsal color pattern is almost black in hue. The ventral color includes many different shades of brown, sometimes darkish, or whitish brown and also ground color of the ventral side is lighter than dorsal side (Figure 3B). This color variation continues across both upper labials and lower labials on each side of head. The specimen has a different color of ventral surface of the end of the tail that is orange (Figure 3C). In addition, references, which are listed in Table 1, indicated that the body color of all known specimens were totally black; however, the ground color of the second specimen of reference 4 was greyish brown with a blackish zig-zag band.

3.3 Species distribution modeling Based on current climatic conditions distribution model of *Pelias barani* showed that some parts of northwest and northeast of Turkey was the areas represented with better predicted conditions for *Pelias barani*'s habitat (Figure 2). As a result of estimates of relative contributions of the environmental variables with Maxent, the most environmental variables with highest gain that explains more than 10% of the presence of *P. barani* were Bio-14 (Precipitation of driest month, 45.5%), Bio-4 (Temperature seasonality, 18.9%), Bio-15 (Precipitation seasonality, 17.9%) and Bio-5 (Maximum temperature of warmest period, 14.7%). Other variables had a percent contribution less than 5%. The average test AUC (the area under the receiver operating characteristic curve) value of the distribution model of *P. barani* was 0.904 ± 0.068 and 10 percentile training presence logistic threshold was 0.3632. Predicted suitability was highest in northwest and northeast regions of Turkey with extreme precipitation conditions that influence potential range of *P. barani* during the year, but with a lower temperature variation throughout the year, low variation in total monthly precipitation throughout the year and low warm temperature anomalies throughout the year (Figure 4).

4. Discussion

There are two-distribution patterns for *P. barani* in Turkey, including the Black Sea Region (Zonguldak, Ordu, Giresun, Trabzon, Rize and Artvin localities) and the Marmara Region (Adapazarı localities). The Black Sea Region has the greatest amount of precipitation in Turkey. Its summer is warm and humid and the winter is cool and

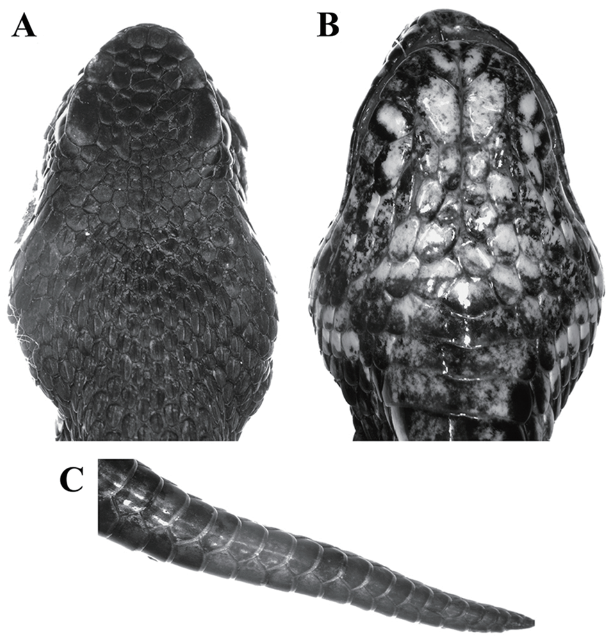

Figure 3 Dorsal (A), and ventral (B) side of typical head pattern, and color of the ventral surface at the end of tail (C) in female specimen from Büyükköy, Çayeli.

damp (Borysova *et al.*, 2005). Marmara Region consists generally of three zones (İstanbul and Yıldız Mountain to the north, İzmir and Ankara to the south, and Sakarya). Therefore, it is the region that has the greatest diversity of climate variable. It has Mediterranean climate that is warm to hot, dry summers and mild to cool, wet winters on the Agean Sea coast and the south Marmara Sea coast, and has an oceanic climate that is warm summers and cool winters on the Black Sea coast (Sertel and Ormeci, 2011). Adapazarı localities found in the Sakarya zone of *P. barani* are similar to the Black Sea Region with regard to climatic features (Sirdaş, 2005). The geographic distribution of *P. barani* that is limited with the north coastal areas of Turkey indicates that this species is not resistant to a wide variety of conditions (eurioic) (Figure 2). *P. barani* has actually been detected in particular regions under very rainy environmental conditions on the Anatolian range. I found that the model, which explains the current distribution pattern of *P. barani*, is based on the precipitation of driest period (Bio-14), Temperature seasonality (Bio-4), Precipitation seasonality (Bio-15) and Maximum temperature of warmest period (Bio-5) of northwest and northeast of Turkey. Summer temperature and precipitation are probably a limitation factor of *P. barani*'s dispersion (Figure 2). Therefore, *P. barani* inhabits towards to the Black Sea region of Turkey. In fact, the geographical structure of Anatolia plays a significant role for a rich biodiversity because the Anatolia generates from multiple glacial refugia (Bilgin, 2011; Tarkhnishvili *et al.*, 2012). This suggests that occurrence of the genetic diversity correlates with differentiation in the ecology of local refugia within Anatolia (Gül, 2013). The important mountain chains, such as Toros Mountains, North Anatolian Mountains, the Anatolian Diagonal and Western Anatolian Mountains, are a barrier affecting the distribution of many amphibians (Gül, 2013; Özdemir *et al.*, 2014) and reptiles (Kapli *et al.*, 2013; Sindaco *et al.*, 2014). Similarly, Brito *et al.* (2008) showed that distribution of the viperid snakes (*Vipera latastei* and *V. monticola*) were influenced by the precipitation of driest period for Eastern Iberia, Algeria, and Rif and Middle Atlas, and High Atlas except Western Iberia. In biogeographical scenario of *Vipera seoanei*, another study represents that the origin of genus *Pelias* can be expanded from the north Black Sea region toward Europe between the late Miocene and early Pliocene, and range expansions of the genus *Pelias* were affected by cooler temperatures of Pleistocene while warm temperatures of middle Pliocene prevailed its expansion (Martínez-Freiría *et al.* 2015). In fact, species of the genus *Pelias* can be better adapted to colder climates (Garrigues *et al.*, 2005). In addition, several studies support that climatic factors are responsible for geographical distribution of many reptile species (Santos *et al.*, 2006; Brito *et al.*, 2008; Brito *et al.*, 2011; Sow *et al.*, 2014; Martínez-Freiría *et al.*, 2015).

Consequently, the *P. barani* specimen with new locality in this study has similarities to specimens in the literature in terms of morphometric measurements (Table 1). Since *P. barani* is a rare species, new locality records are very important in order to understand the distributional ranges of the species. In addition, this study represents that climatic conditions restricts its potential distribution in Turkey, and also it has been suggested that local precipitation patterns was important for the distribution model of the species.

According to IUCN Red List, *P. barani* (*Vipera barani* in IUCN) is listed as near threatened (NT) and it is known as pontic endemic (Venchi and Sindaco, 2006). Population trend of *P. barani* has been decreased because of habitat loss, and persecution. Similarly, I observed habitat loss caused by destruction of forest through commercial harvest and construction of roads in Büyükköy locality. In addition, it is killed like many snakes when *P. barani* is seen by the local people. I also realized that many amphibians and reptiles were being killed on roads, and thought that *P. barani* might be killed like others. Therefore, habitat destruction, road deaths and deaths

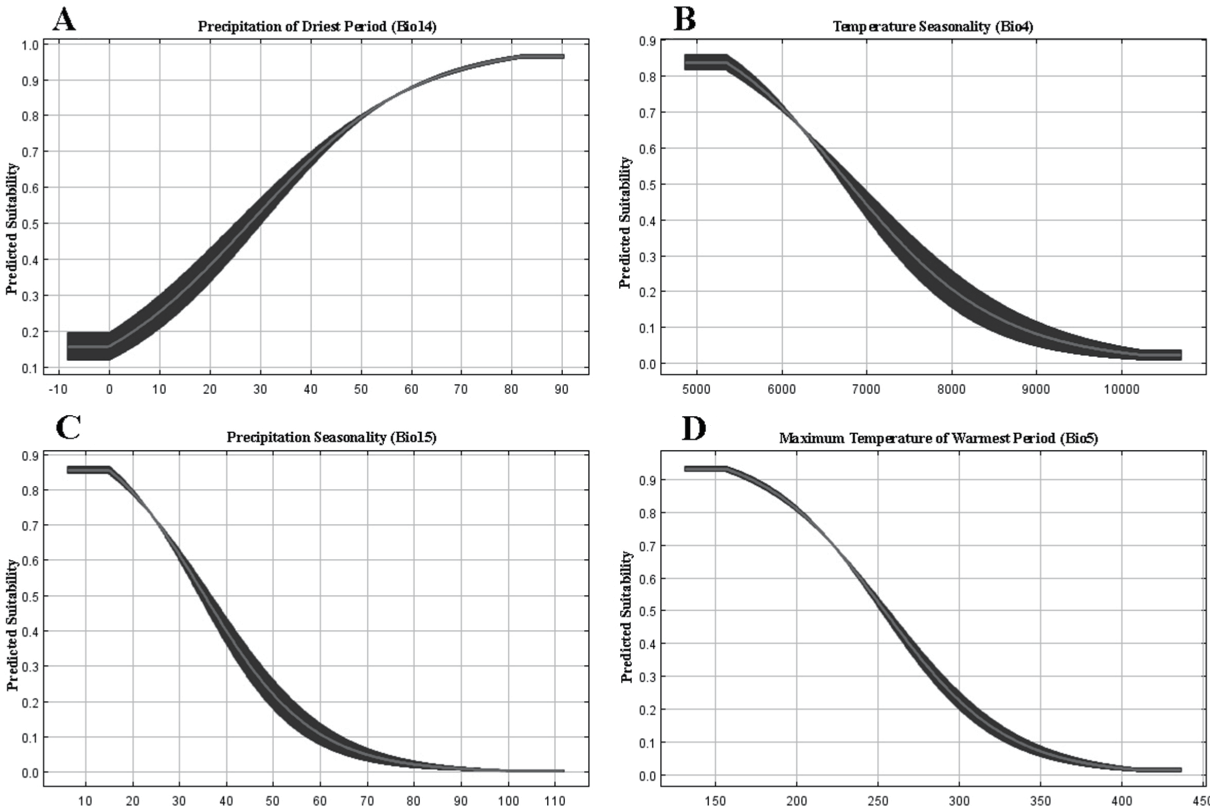

Figure 4 Response curves of the four bioclimatic variables that limit the distribution of *P. barani*. (A) Precipitation of driest period (Bio14), (B) Temperature seasonality (Bio4), (C) Precipitation seasonality (Bio15) and (D) Maximum temperature of warmest period (Bio5).

caused by local human activities is a major threat to survival of *P. barani* and significant cause of extinction of *P. barani* throughout Black Sea coast. As a result of all these threats, it might be candidate to enter Vulnerable (VU) category under the red list category in the near future. Literature information about its distribution and ecology are very scarce. Therefore, it's a new locality record and climatic preferences might be useful for conservation of this pontic endemic viper.

References

Afsar M., Afsar B. 2009. A new locality for *Vipera* (*Pelias*) *kaznakovi* Nikolsky, 1909 (Reptilia, Viperidae) in the north-eastern Anatolia. Russ J Herpetol,16:155–158

Ananjeva N. B., Orlov N. L., Khalikov R. G., Darevsky I. S., Ryabov I. S. Barabanov A. V. 2006. The Reptiles of Northen Eurasia: Taxonomic diversity, distribution, conservation status. Pensoft Series Faunistica, No. 47, 245pp

Avcı A., Üzüm N., Olgun K. 2004. A new record of *Vipera barani* Böhme and Joger, 1983 (Reptilia, viperidae) from north-eastern Anatolia, Turkey. Russ J Herpetol, 11: 77–79

Avcı A., Ilgaz Ç., Baskaya S., Baran İ., Kumlutas Y. 2010. Contribution to the distribution and morphology of *Pelias darevskii* (Vedmederja, Orlov et Tuniyev 1986) (Reptilia: Squamata: Viperidae) in northeastern Anatolia. Russ J Herpetol, 17: 1–7

Baran İ., Tosunoğlu M., Kaya M., Kumlutaş Y. 1997. On the herpetofauna of the vicinity of Çamlıhemşin. Turk J Zool, 21: 409–416

Baran İ. Joger U., Kutrup B., Türkozan O. 2001. On new specimens of *Vipera barani* Böhme and Joger, 1983 from northeastern Anatolia, and implications for the validity of *Vipera pontica* Billing, Nilson and Sattler, 1990 (Reptilia, Viperidae). Zool Mid East, 19: 33–36

Baran İ. Kumlutaş Y., Ilgaz Ç., Iret F. 2005. Geographical distributions and taxonomical states of *Telescopus fallax* (Fleischman, 1831) and *Vipera barani* Böhme and Joger, 1983. Turk J Zool, 29: 217–224

Beyer H. L. 2012. Geospatial Modelling Environment (Version 0.7.2.0). (software). URL: 279 http://www.spatialecology.com/gme.

Bilgin R. 2011. Back to the suture: The distribution of intraspecific genetic diversity in and around Anatolia. Int J Mol Sci, 12: 4080–4103

Borysova O., Kondakov A., Paleari S., Rautalahti-Miettinen E., Stolberg F., Daler D. 2005. Eutrophication in the Black Sea region; impact assessment and causal chain analysis. University of Kalmar, Kalmar, Sweden, 60pp

Böhme W., Joger U. 1983. Eine neue Art des *Vipera berus*-Komplexes aus der Turkei. Amphibia-Reptilia, 4: 265–271

Brito J. C., Santos X., Pleguezuelos J. M., Sillero N. 2008. Inferring evolutionary scenarios with geostatistics and geographical information systems for the viperid snakes *Vipera*

latastei and *Vipera monticola*. Biol J Linnean Soc, 95: 790–806

Brito J.C. Fahd S., Geniez P., Martínez-Freiría F., Pleguezuelos J. M., Trape J. F. 2011. Biogeography and conservation of viperids from North-West Africa: an application of ecological niche-based models and GIS. J Arid Environ, 75: 1029–1037

Franzen M., Heckes U. 2000. *Vipera barani* Böhme and Joger, 1983 aus demöstlichen Pontus-Gebirge, Türkei: Differentialmerk-male, verbreitung, Habitate. Spixiana, München, 23: 61–70

Garrigues T., Ferquel C. E., Choumet V., Failloux A. B. 2005. Molecular phylogeny of *Vipera* Laurenti, 1768 and the related genera *Macrovipera* (Reuss, 1927) and *Daboia* (Gray, 1842), with comments about neurotoxic *Vipera aspis aspis* populations. Mol Phylogenet Evol, 35: 35–47

Göçmen B., Mebert K., Iğci N., Akman B., Yıldız M. Z., Oğuz M. A., Altın Ç. 2014. New locality records for four rare species of vipers (Reptilia: Viperidae) in Turkey. Zool Mid East, 60: 306–313

Graham K. H., Ron S. R., Santos J. C., Schneider C. J., Moritz C. 2004. Integrating phylogenetics and environmental niche models to explore speciation mechanisms in dendrobatid frogs. Evolution, 58: 1781–1793

Gül S. 2013. Ecological divergence between two evolutionary lineages of *Hyla savignyi* (Audouin, 1827) in Turkey: Effects of the Anatolian Diagonal. Anim Biol, 63: 285–295

Hijmans R. J., Cameron S. E., Parra J. L., Jones P. G., Jarvis A. 2005. Very high resolution interpolated climate surfaces for global land areas. Int J Climatol, 25: 1965–1978

Iucn 2014. IUCN Red List of Threatened Species. Version 2014.1. [www.iucnredlist.org]. Downloaded on 22 October 2014.

Joger U., Lenk P., Baran I., Böhme W., Ziegler T., Heidrich P., Wink M. 1997. The phylogenetic position of *Vipera barani* and of *V. nikolskii* within the *Vipera berus complex*. In Böhme W., Bischoff W., Ziegler T. (Eds), Herpetologia Bonnensis. Bonn (Zoologisches Forschungsinstitut und Museum A. koenig), 185–194

Joger U., Kalyabina-Hauf S. A., Schweiger S., Mayer W., Orlov N. L., Wink M. 2003. Phylogeny of Eurasian *Vipera* (Subgenus *Pelias*). 12th Ord Gen Meet S.E.H., St. Petersburg, Russia, 12-16 August 2003. Abstracts: 77

Kalyabina-Hauf S., Schweiger S., Joger U., Mayer W., Orlov N., Wink M. 2004. Phylogeny and systematics of adders (*Vipera berus complex*). Mertensiella, 15: 7–15

Kapli P., Botoni D., Ilgaz Ç., Kumlutaş Y., Avcı A., Rastegar-Pouyani N., Fathinia B., Lymberakis P., Ahmadzadeh F., Poulakakis N. 2013. Molecular phylogeny and historical biogeography of the Anatolian lizard *Apathya* (Squamata, Lacertidae). Mol Phylogenet Evol, 66: 992–1001

Kozak, K. H., Graham C. H., Wiens J. J. 2008. Integrating GIS data into evolutionary studies. Trends Ecol Evol, 23: 141–148

Kumlutaş Y., Sözen M., Ilgaz Ç. 2012. New record of the rare *Vipera barani* Böhme and Joger, 1983. Herpetozoa, 25: 183–188

Martínez-Freiría F., Velo-Antón G., Brito J. C. 2015. Trapped by climate: interglacial refuge and recent population expansion in the endemic Iberian adder *Vipera seoanei*. Divers Distrib, 21: 331–344

Özdemir N., Gül S., Poyarkov N. A., Kutrup B., Tosunoğlu M., Doglio S. 2014. Molecular systematics and phylogeography of *Bufotes variabilis* (syn. *Pseudepidalea variabilis*) (Pallas, 1769) in Turkey. Turk J Zool, 38: 412–420

Phillips S. J., Anderson R. P., Schapire R. E. 2006. Maximum entropy modeling of species geographic distributions. Ecol Model, 190: 231–259

Pyron R. A., Burbrink F. T., Wiens J. J. 2013. A phylogeny and updated classification of Squamata, including 4161 species of lizards and snakes. BMC Evol Biol, 13: 93

Santos X., Brito J. C., Sillero N., Pleguezuelos J. M., Llorente G. A., Fahd S., Parellada X. 2006. Inferring habitat-suitability areas with ecological modelling techniques and GIS: A contribution to assess the conservation status of *Vipera latastei*. Biol Cons, 130: 416–425

Sertel E., Ormeci C. 2011. Modelling land cover change impact on the summer climate of the Marmara Region, Turkey. Int J Glob Warm, 3: 194–202

Sindaco R., Panagiotis K., Roberto S., Petros L. 2014. Taxonomic reassessment of *Blanus strauchi* (Bedriaga, 1884) (Squamata: Amphisbaenia: Blanidae), with the description of a new species from south-east Anatolia (Turkey). Zootaxa, 3795: 311–326

Sirdaş S. 2005. Daily wind speed harmonic analysis for Marmara region in Turkey. Energ Convers Manage, 46: 1267–1277

Sow A. S., Martinez-Freiria F., Dieng H., Fahd S., Brito J. C. 2014. Biogeographical analysis of the Atlantic Sahara. Reptiles: Environmental correlates of species distribution and vulnerability to climate change. J Arid Environ, 109: 65–73

Tarkhnishvili D., Gavashelishvili A., Mumladze L. 2012. Palaeoclimatic models help to under- stand current distribution of Caucasian forest species. Biol J Linn Soc, 105: 231–248

Tuniyev S. B., Avcı A., Tuniyev B. S., Agasian A. L., Agasian L. A. 2012. Description of a new species of Shield-Head Vipers *Pelias olguni* sp. nov. from basin of upper flow of the Kura River in Turkey. Russ J Herpetol, 19: 314–332

Venchi A., Sindaco R. 2006. Annotated checklist of the reptiles of the Mediterranean countries, with keys to specific identification. Part 2—Snakes (Reptilia, Serpentes). Annali del Museo Civico di Storia Naturale "Doria G.", Genova, 98: 259–364

Wallach V., Williams K. L., Boundy J. 2014. Snakes of the World: A Catalogue of Living and Extinct Species. Boca Rattan, FL: CRC Press, 1237pp

Warren D. L., Glor R. E., Turelli M. 2010. ENMTools: A toolbox for comparative studies of environmental niche models. Ecography, 33: 607–611